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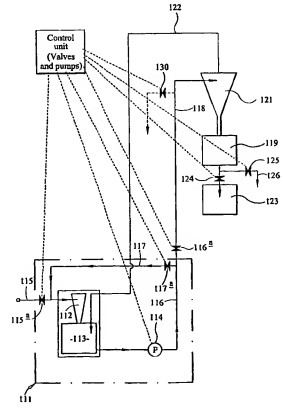
(54) Title: SAND TRANSPORT SYSTEM



(57) Abstract: A process for the batch transport of sand, comprising mixing a predetermined quantity of sand contained in a first accumulation vessel (113) at a first location into a slurry with water, pumping the slurry to a second, remote location, passing the slurry through a sand cyclone (121) at said second location to separate the slurry into sand and water, collecting the sand from the underflow of the cyclone in a second accumulation vessel (119) at said second location, recirculating (122) water from the reject of the cyclone through said first vessel (113) to flush remaining sand of said predetermined quantity of sand from said first vessel to the sand cyclone.

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SAND TRANSPORT SYSTEM

Technical Field

This invention relates to a sand transport system for use in the processing of a hydrocarbon well production stream.

Background Art

Hydrocarbon wells, for example oil or gas wells, can include sand as part of the well production stream. Such sand must be separated from the production stream and is either dumped, for example overboard a sea-based production platform, or in some cases re-injected into the hydrocarbon bearing strata from which the production stream is derived. Thus there is often a need to transport sand from one region or item of processing apparatus to another. Simply pumping a sand slurry from one location in a hydrocarbon processing installation to another is problematic, particularly where vertical transport is needed, as at the termination of pumping sand remaining in the transport system can settle out of the slurry clogging valves and other parts of the transport system.

A particular problem arises when, rather than disposing of the sand overboard the platform it is desired to supply some or all of the sand to a re-injection plant, usually known as a Cuttings Re-injection Plant (CRI plant). It is easier to pump high water content slurries but this can be problematic as conventional CRI plants are not designed to handle high water content sand slurries. A CRI plant will normally be displaced by some distance, and by perhaps some height from the washing system, and although the accumulation vessel of a sand separation unit or a sand washing unit can be arranged to

supply a slurry which is around 30% sand by volume (this being the sand/water concentration preferred for optimal operation of the CRI plant) transporting 30% sand slurries is problematic, particularly where the CRI plant is elevated significantly above the washing system. The transport of 30% by volume sand slurries requires a heavy duty pump and motor and can be expensive as it entails high wear rates and consequential frequent maintenance of pump parts. Furthermore, at times when the slurry is not being transported then the lines connecting the separation or washing unit and the CRI plant can become settlement vessels in which substantial amounts of sand settle, clogging the lines and valves in the lines. Where there is a height difference between the washing system and the CRI plant the difficulties are exacerbated.

It is an object of the present invention to provide an improved sand transport system for use hydrocarbon well production stream processing apparatus.

Frequently sand separated from a production stream will be contaminated with oil which is adsorbed onto the surface of the sand particles. It is desirable to remove and recover this oil if possible, particularly where the sand is to be discharged overboard a sea-based production platform. Many territories have strict regulations with regard to the amount of oil contamination which can be tolerated in sand being dumped overboard the production platform. Thus certain preferred embodiments of the invention involve a sand washing unit.

A number of different sand washing units are known, an example being a "G-Sep de-sander" supplied by Kvaerner Process Systems a.s. In a "G-Sep

de-sander" contaminated sand is subjected to high shear forces in a water based slurry by being passed through a centrifugal recirculation pump and through a cyclone separator. The high shear forces disrupt the adherence of the oil film or droplets to the sand particles and it is known that such techniques can produce sand which is sufficiently clean to be discharged overboard a sea-based production platform. The "G-Sep de-sander" and other washing systems are usually operated in batch mode and include an accumulation vessel into which a water based slurry of clean sand flows, and wherein the clean sand accumulates for batch disposal.

Disclosure of Invention

In accordance with a first aspect of the present invention there is provided a process for the batch transport of sand, comprising mixing a predetermined quantity of sand contained in a first accumulation vessel at a first location into a slurry with water, pumping the slurry to a second, remote location, passing the slurry through a sand cyclone at said second location to separate the slurry into sand and water, collecting the sand from the underflow of the cyclone in a second accumulation vessel at said second location, recirculating water from the reject of the cyclone through said first vessel to flush remaining sand of said predetermined quantity of sand from said first vessel to the sand cyclone.

Preferably said first vessel is of larger volume than said second vessel so that for a given quantity of sand the first vessel will contain a sand/water slurry of lesser concentration than that in the second vessel.

Preferably a CRI plant is positioned downstream of the second vessel to receive, in use, the higher concentration sand/water slurry therefrom.

In accordance with a second aspect of the present invention there is provided a sand transport system comprising a sand handling unit from which a slurry of sand and water can be derived, a cuttings re-injection (CRI) plant disposed remote from said sand handling unit, a sand cyclone disposed adjacent said CRI plant, a feed line including a slurry pump connecting an outlet of the sand handling unit and the inlet of said sand cyclone, a water return line connecting the reject port of said sand cyclone with said sand washing unit, a sand accumulation vessel receiving from the underflow of said sand cyclone sand separated from said slurry by said sand cyclone, and means for discharging sand from said accumulation vessel to said CRI plant.

Preferably said sand handling unit is arranged to produce a dilute sand and water slurry for transporting to said sand cyclone and said accumulation vessel is so dimensioned in relation to a predetermined batch of sand delivered thereto by said sand cyclone that a more concentrated sand and water slurry is discharged from said accumulation vessel to said CRI plant.

Conveniently said first sand handling unit is a sand separation unit.

Desirably said first sand handling unit is a sand washing unit.

Preferably where said sand handling unit is a sand washing unit then said slurry is pumped to said sand cyclone by a slurry pump of the sand washing unit.

In accordance with a third aspect of the present invention there is provided a sand disposal system comprising a sand washing unit to which contaminated sand is delivered, and from which either a slurry of clean sand and water or a slurry of substantially unwashed sand and water can be derived, a cuttings re-injection (CRI) plant disposed remote from said sand washing unit, a sand cyclone disposed adjacent said CRI plant, a feed line including a slurry pump connecting an outlet of the sand washing unit and the inlet of said sand cyclone, a water return line connecting the reject port of said sand cyclone with said sand washing unit, a sand accumulation vessel receiving from the underflow of said sand cyclone sand separated from said slurry by said sand cyclone, means for selectively either, discharging sand from said accumulation vessel to said CRI plant or discharging sand elsewhere for disposal, and, control means operable to effect either operation of said washing unit in a non-wash mode so that a slurry of substantially unwashed sand and water is supplied to said sand cyclone and in conjunction therewith to effect discharge of sand from said accumulation vessel to said CRI plant for disposal, or operation of said washing unit in a wash mode so that a slurry of washed sand and water is discharged other than to said CRI plant for disposal.

Conveniently washed sand is discharged upstream of the sand cyclone inlet.

Brief Description of the Drawing

The accompanying drawing is a diagrammatic representation of a sand transport system in accordance with one example of the present invention.

Preferred Mode for Carrying Out the Invention

Referring to the accompanying drawing, sand derived from a hydrocarbon well production stream is delivered to a sand handling unit located in the production stream processing area of the production platform or plant. The sand handling unit can take a number of forms including a sand separation unit and a sand holding unit which may be the collection pot of a sand separation unit. However, because in certain circumstances the sand, which may be contaminated with oil droplets or oil film, may need to be washed before being disposed of, the unit is conveniently a generally conventional sand washing unit 111 (the unit enclosed within the chain dotted boundary in Figure 2) which is capable of being operated in a non-washing mode and which may incorporate minor modifications as appropriate to adapt it to the present invention. The exact nature of the washing unit is not of critical importance to the present invention and the sand washing unit which will be described is a G-Sep de-sander supplied by Kvaerner Process Systems a.s..

The sand separation unit/washing unit 111 will be well understood by those skilled in the art and generally includes a sand cyclone 112, an accumulation vessel 113, and a centrifugal pump 114. A slurry of contaminated sand in water is supplied to an inlet of the washing unit 111 by way of a supply line 115 containing a remotely operable valve 115a. In operation, the valve 115a is opened to permit a predetermined quantity of sand to be supplied to the washing unit. Sand is supplied through the line 115 to the unit 111 until a batch of sand of predetermined weight or volume settles into the accumulation vessel 113. Thereafter the valve 115a is closed. The predetermined quantity of sand and the volume of the vessel 113 are chosen

to provide a desired sand/water slurry concentration in the vessel 113, in this case about 5% sand, 95% water.

When the unit 111 is operated in washing mode the accumulated sand in the vessel 113 is agitated with the water in the vessel to produce a fluid slurry (of about 5% sand, 95% water by volume) which is pumped by the pump 114 through a line 116, and a line 117 containing a remotely operated valve 117a, to the inlet of the sand cyclone 112. Shear forces in the slurry pump 114 and the sand cyclone 112 remove the adsorbed oil from the sand surface by attrition and abrasion. Sand passes through the sand cyclone and exits, by way of the underflow port of the sand cyclone, into the accumulation vessel 113.

Separated water containing oil droplets dislodged from the sand particles exits the sand cyclone through the reject port and is routed back into the vessel 113 so that sand and water passing through the sand cyclone into the accumulation vessel 113 remain in the form of a fluid slurry which is returned around the recirculation loop by the pump 114 to be further subjected to shear forces in the pump 114 and again in the sand cyclone 112. After a predetermined time the operation of the pump 114 ceases, recirculation stops, and the batch of sand which has been recirculated a number of times, and is now clean, settles in the accumulation vessel 113. The oil droplets in the water migrate to the top of the vessel 113 from where they are flushed for subsequent discharge/processing in known manner.

The line 116 which connects the outlet of the pump 114 through the valve 117a to the line 117 includes, beyond the connection with the line 117, a

remotely operated valve 116a. The valve control arrangement of the system ensures that when the valve 116a is open the valve 117a is closed and vice versa.

A CRI plant 123 is disposed remote from the washing unit 111. As mentioned the unit 111 will be in the well stream processing area of the production platform, whereas normally the CRI plant will be located at the drilling area of the platform remote from the well stream processing area

The CRI plant itself is conventional and will be well understood by those skilled in the art, its function being to receive sand separated elsewhere and to return it into the strata from which the well production stream was derived. As will be well understood the conventional CRI plant operates most efficiently when it is supplied with a sand/water slurry having a concentration of the order of 30% sand to 70% water by volume. As mentioned previously the CRI plant 123 maybe a considerable distance away from the washing unit 111 and, because of constraints imposed by the remainder of the production facility, the CRI plant 123 may be elevated considerably above the washing unit.

In one example the CRI plant is disposed 38 metres above the sand washing unit 111. Transport of 30:70 sand/water slurries is problematic. Such high concentrations of sand tend to promote settlement of the sand in the lines, and the quantities of sand involved necessitate the use of heavy duty pumps and motors and entail high wear rates and frequent maintenance. These problems are exacerbate by the preferred use of relatively small diameter lines and low flow rates to deliver sand to a CRI plant. Such difficulties are mitigated in

accordance with the present invention by providing a sand cyclone 121 and an associated accumulation vessel 119 adjacent the inlet of the CRI plant 123.

An extension 118 of the line 116 is connected to the inlet of the sand cyclone 121 so that when the valve 116a is open and the valve 117a is closed the output of the pump 114 flows through the line 116, 118 to the inlet of the sand cyclone 121. A water return line 122 collects water from the reject (also known as the overflow outlet or overflow port) of the sand cyclone 121 and returns it to the accumulation vessel 113 of the washing unit 111.

The operation of the apparatus is as follows. A batch of sand in the vessel 113 of the unit 111 is agitated with the water in the vessel to produce a slurry at a concentration of approximately 5%sand to 95% water by volume. With the valve 116a open, the valve 115a closed, and the valve 117a closed, the pump 114 is operated to pump the slurry through the line 116, the valve 116a, and the line 118 to the inlet of the sand cyclone 121. The sand cyclone 121 separates sand and water such that sand passes from the underflow of the sand cyclone 121 (also referred to a the underflow outlet or the underflow port) and into the water filled accumulation vessel 119. The separated water is returned by the line 122 from the reject of the sand cyclone 121 to the accumulation vessel 113 of the washing unit where it acts to flush additional sand from the vessel 113, through the pump 114, and the lines 116 and 118 to the sand cyclone 121. The recirculation of water by way of the line 122 is allowed to continue for a predetermined amount of time to ensure that all sand has been flushed from the washing unit 111 to the vessel 119. Thereafter the pump 114 is stopped, the valve 116a is closed, the valve 117a

is opened, and the valve 115a is opened to allow a new batch of contaminated sand to enter the washing unit 111. Thereafter the process is repeated.

As mentioned above the volume of the vessel 113 is so chosen in relation to the weight of sand processed in each batch operation (for example 500 kg) that the concentration of the sand slurry in the vessel 113 is 5% sand and 95% water and so is easy to transport. The vessel 119 is smaller than the vessel 113 such that the same quantity of sand, when transported to the smaller vessel 119 produces a 30% sand and 70% water slurry concentration more suitable for, for example, the CRI plant 123.

It will be recognised that because the recirculation of water through the line 122 back to the washing unit 111 is continued until all sand has been flushed through the system there is no danger of sand settlement blocking the line 118 during a subsequent washing cycle while the valve 116a is closed.

If it is necessary to wash the batch of contaminated sand delivered to the washing unit 111 from the line 115 and then with the valve 116a closed, the valve 115a closed, and the valve 117a open, the pump 114 is operated to recirculate a sand/water slurry around the washing unit in known manner as mentioned above. After washing for a predetermined length of time and removal of the displaced contaminating oil from the vessel 113, the valve 117a is closed and the valve 116a is opened to allow the slurry to be pumped to the sand cyclone 121 as described above.

It will further be recognised that the pump 114 is the slurry recirculation pump of the conventional washing unit 111, and thus an additional pump to convey the sand to the vessel 119 is unnecessary.

Sand collected in the vessel 119 can be discharged into the CRI unit 123 for re-injection by opening a valve 124, or can be discharged elsewhere (for example overboard the production platform) by closing the valve 124 and opening a valve 125 controlling a discharge line 126. It will be understood that there is usually no need to wash sand before re-injection and so where the CRI unit 123 is operative the main system control arrangement can cause the washing unit to be operated in a non-wash mode in which the recirculation sequence in the unit 111 is dispensed with and the contaminated (substantially unwashed) sand is transported from the unit 111 to the separation unit 119, 121 and the CRI unit 123. However should the CRI unit become inoperative the control arrangement will cause the washing sequence in the unit 111 to be commenced and will cause the valves 124 and 125 to be operated so that washed sand is discharged overboard the platform by way of the line 126 and not to the CRI unit 123. Only a change in the mode of operation, and no change in the apparatus, is needed to effect the change in the disposal route of the sand. It will be understood that if desired the valve 125 and line 126 could be replaced by a valve and sand discharge line upstream of the inlet of the cyclone 121 (shown in broken lines at 130 in the drawing) so that washed sand can be discharged directly from the washing unit 111 by the pump 114.

Although the invention finds particular advantage where the sand is transported to a higher elevation, the invention is nevertheless advantageous

in other sand transport situations where there is not an increase in elevation.. Of particular importance is both the recirculation of the water separated by the sand cyclone so that the whole batch of sand is ultimately flushed from the accumulation vessel of a first handling unit to the second handling unit, thereby avoiding problems arising from sand settlement in the transporting lines between sequential transport operations; and the slurry concentration control which permits easy transport of dilute slurry and operation of the downstream CRI plant at its optimum, higher slurry concentration..

Claims :-

1. A process for the batch transport of sand, characterised by comprising mixing a predetermined quantity of sand contained in a first accumulation vessel (113) at a first location into a slurry with water, pumping the slurry to a second, remote location, passing the slurry through a sand cyclone (121) at said second location to separate the slurry into sand and water, collecting the sand from the underflow of the cyclone in a second accumulation vessel (119) at said second location, recirculating (122) water from the reject of the cyclone through said first vessel (113) to flush remaining sand of said predetermined quantity of sand from said first vessel to the sand cyclone.

2. A process for the batch transport of sand as claimed in claim 1, characterised in that said first vessel (113) is of larger volume than said second vessel (119) so that for a given quantity of sand the first vessel will contain a sand/water slurry of lesser concentration than that in the second vessel.

3. A process for the batch transport of sand as claimed in claim 2, characterised in that a CRI plant (123) is positioned downstream of the second vessel (119) to receive, in use, the higher concentration sand/water slurry from said second vessel (119).

4. A sand transport system characterised by comprising a sand handling unit (111) from which a slurry of sand and water can be derived, a cuttings re-injection (CRI) plant (123) disposed remote from said sand handling unit (111), a sand cyclone (121) disposed adjacent said CRI plant, a feed line

(116) including a slurry pump (114) connecting an outlet of the sand handling unit (111) and the inlet of said sand cyclone (121), a water return line (122) connecting the reject port of said sand cyclone with said sand washing unit, a sand accumulation vessel (119) receiving from the underflow of said sand cyclone sand separated from said slurry by said sand cyclone (121), and means (124) for discharging sand from said accumulation vessel to said CRI plant.

5. A sand transport system as claimed in claim 4 characterised in that said sand handling unit (111) is arranged to produce a dilute sand and water slurry for transporting to said sand cyclone (121) and said accumulation vessel (119) is so dimensioned in relation to a predetermined batch of sand delivered thereto by said sand cyclone that a more concentrated sand and water slurry is discharged from said accumulation vessel (119) to said CRI plant (123).

6. A sand transport system as claimed in claim 4 or claim 5 characterised in that said first sand handling unit is a sand separation unit.

7. A sand transport system as claimed in any one of claims 4 to 6 characterised in that said first sand handling unit is a sand washing unit.

8. A sand transport system as claimed in claim 7 characterised in that said slurry is pumped to said sand cyclone by a slurry pump (114) of the sand washing unit.

9. A sand disposal system characterised by comprising a sand washing unit (111) to which contaminated sand is delivered, and from which either a slurry of clean sand and water or a slurry of substantially unwashed sand and water can be derived, a cuttings re-injection (CRI) plant (123) disposed remote from said sand washing unit, a sand cyclone (121) disposed adjacent said CRI plant, a feed line (116) including a slurry pump (114) connecting an outlet of the sand washing unit and the inlet of said sand cyclone, a water return line (122) connecting the reject port of said sand cyclone with said sand washing unit, a sand accumulation vessel (119) receiving from the underflow of said sand cyclone sand separated from said slurry by said sand cyclone, means for selectively either, discharging sand from said accumulation vessel (19) to said CRI plant (123), or discharging sand elsewhere for disposal, and, control means operable to effect either operation of said washing unit in a non-wash mode so that a slurry of substantially unwashed sand and water is supplied to said sand cyclone and in conjunction therewith to effect discharge of sand from said accumulation vessel to said CRI plant for disposal, or operation of said washing unit in a wash mode so that a slurry of washed sand and water is discharged other than to said CRI plant for disposal.

10. A sand disposal system as claimed in claim 9 characterised in that washed sand is discharged upstream of the inlet of said sand cyclone.

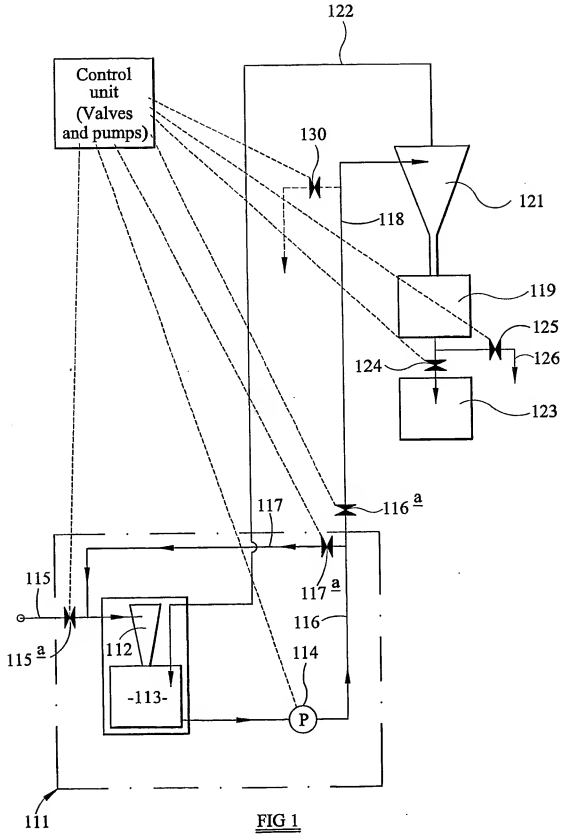
122
Control unit (Valves and pumps)
130
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FIG 1

INTERNATIONAL SEARCH REPORT

Internati pplication No
PCT/ib 03/03458

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/40 E21B41/00 B09C1/02 B03B9/02 E21B21/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B B09C B03B B65G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 November 2003	10/11/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Dantinne, P

Form PCT/ISA/210 (second sheet) (July 1992)

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB 03/03458

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